

Remarks

Thorough examination by the Examiner is noted and appreciated.

The Claims have been amended and a new claim added to clarify Applicants disclosed and claimed invention. Support for the amended claims is found in the original claims and/or Specification. No new matter has been entered. Specifically, support for new limitations in claims 1 and new claim 21 is found in the Specification e.g., at paragraph 0028:

"For example, Figure 4 shows cyclic voltometry data of a copper electrode in an acidic cleaning solution with a pH of about 4. The vertical axis is the log of current density while the horizontal axis is oxidation potential in Volts versus a reference Ag/AgCl electrode. Other relevant operating parameters include a spin rate for the electrode of about 2000 rpm and a scan rate of about 0.01 V/sec. Line A represents the electrochemical oxidation potential under normal conditions including having the electrode subject to incident light (having a wavelength of about 350 to about 700 nm) while contacting the cleaning solution. **Line B represents the electrochemical oxidation potential under substantially light shielded conditions (dark conditions)**, e.g., incident light upon the electrode while in contact with the cleaning solution is substantially blocked from impacting the electrode. The shift of the minimum (e.g., C1) in current density to more positive electrochemical oxidation potential under dark conditions (e.g., C2) is analogous to **what is believed to be an increase of the activation energy for formation of copper oxide (e.g., CuO or Cu<sub>2</sub>O) or copper hydroxide (e.g.,**

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Cu(OH)<sub>2</sub>) thereby slowing the rate of erosion of the copper metal interconnect lines."

**Claim Rejections under 35 USC 112**

1. Claim 3 is rejected under 35 USC 112, second paragraph as being indefinite for failing to particularly and distinctly claim the subject matter which Applicants regard as their invention.

Claim 3, has been amended to overcome Examiners rejection.

**Claim Rejections under 35 USC 102**

2. Claims 10-12 and 15-20 stand rejected under 35 USC 102(b) or (e) as being anticipated by Edelstein et al. (US Pat. 6,251,787) or 6,153,043). Note that citations are to 6,251,787.

Edelstein et al. discloses and teaches **eliminating exposure of PN junctions to light** capable of invoking a photovoltaic reaction to prevent electrochemical dissolution of metal components in contact with an electrolyte (see Abstract; col 5, lines 25-34). Edelstein further teaches eliminating exposure to light having wavelengths less than about 1.1 micron for silicon wafers and 0.9 microns for GaAs wafers. Edelstein et al. generally disclose that in general tools may have a darkened enclosure to eliminate exposure of PN junctions, specifically

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disclosing CMP, brush cleaning, unloading, and rinsing (col 7, lines 56-57).

In contrast, Applicants claimed invention claims:

"A method for preventing [a] photo-induced chemical attack on a copper oxide containing surface comprising the steps of:

providing a substrate comprising a dielectric material and an exposed copper containing surface comprising copper oxide;

providing an acidic cleaning solution for contacting the exposed copper containing surface; and,

shielding the exposed copper containing surface to substantially block incident light from impacting the exposed copper containing surface while contacting the exposed copper containing surface with the acidic cleaning solution."

Nowhere do Edelstein et al. disclose an acidic cleaning solution for contacting the exposed copper containing surface comprising copper oxide.

In addition, nowhere do Edelstein et al. disclose or teach "shielding the exposed copper containing surface to substantially block incident light from impacting the exposed copper containing surface while contacting the exposed copper containing surface with the acidic cleaning solution".

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Nowhere do Edelstein et al. disclose exposed copper surfaces comprising copper oxide.

Edelstein et al. is clearly insufficient to anticipate Applicants disclosed and claimed invention.

**Claim Rejections under 35 USC 103**

3. Claims 1-9 and 13-14 stand rejected under 35 USC 103(a) as being unpatentable over Edelstein et al., above, in view of Obeng et al. (US Pat. 6,323,131), Zhang et al. (US Pat. 6,162,301) and Kneer (US Pat 6,147,002).

Applicants reiterate the comments made above with respect to Edelstein et al.

Applicants further note that Applicants do not disclose or teach blocking a PN junction from light illumination in communication with copper interconnects.

Applicants specifically disclose and claim:

"shielding the exposed copper containing surface to substantially block incident light from impacting the exposed copper containing surface while contacting the exposed copper containing surface with the acidic cleaning solution"

The teachings of Edelstein et al., by **teaching blocking of PN junctions** from light exposure teach away from Applicants disclosed and claimed invention. Applicants do not disclose or teach that illumination of a PN junction and associated electrolysis as the principal of operation as Applicants make apparent in the Specification by the presentation of experimental results relating to light exposure of a copper electrode and a **copper oxide containing surface in contact with an acidic solution**. Moreover, the fact that blocking of PN junctions from light illumination (e.g., wafer backside) as taught by Edelstein et al. might also block illumination of copper oxide containing surfaces is merely a fortuitous circumstance dependent on the position of an illumination source and the wafer.

Edelstein et al. do not teach a copper oxide containing surface or the effect of an acidic cleaning solution in contact therewith or the effect of shielding the copper oxide surface from light illumination while contacting the acidic cleaning solution.

In addition Edelstein et al. teach away from Applicants disclosed and claimed invention by teaching either a **CMP slurry or rinse water** as the electrolyte (see e.g., col 7, line 37, col 8, line 35). Significantly, Edelstein et al. also teaches away

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from Applicants disclosed and claimed invention by teaching a post-CMP water rinse (e.g., col 8, line 14; line 35) rather than an acidic cleaning solution as claimed and disclosed by Applicants.

Moreover, Applicants do not limit their disclosed and claimed invention to the requirement that a semiconductor material or a PN junction be blocked from light illumination, or limit the mechanism of chemical attack (e.g., corrosion) to electrolysis.

"A prior art reference must be considered in its entirety, i.e., as a whole including portions that would lead away from the claimed invention." *W.L. Gore & Associates, Inc., Garlock, Inc., 721 F.2d, 1540, 220 USPQ 303 (Fed Cir. 1983), cert denied, 469 U.S. 851 (1984).*

Applicants note that Examiner admits that Edelstein et al. do not teach or disclose an acidic cleaning solution including Applicants claimed pH ranges.

Examiner, however, claims that the secondary references all teach that conventional cleaning solutions used in conventional steps of post-CMP cleaning of structures with exposed copper are acidic and have the claimed pH.

Examiner does not point to specific combinations of teachings justifying combining the references nor identify a suggestion to combine the references found in the references.

Obeng et al. which refers to forming a corrosion protection passivation layer on an exposed copper surface (see Abstract); Applicants can find nowhere where an acidic cleaning solution is taught by Obeng et al. Further, the method of Obeng et al. would render the method of blocking PN junction illumination and electrolysis reaction of Edelstein et al. obsolete, since the electrolysis reaction could not take place through the passivation layer.

On the other hand, Zhang et al. teach an acidic cleaning solution for cleaning a wafer surface post-CMP following polishing a copper layer (see Abstract).

There is no teaching in Zhang et al. that the acid cleaning solution may act as an electrolyte or that chemical reaction may take place with copper oxide in the presence of light illumination as disclosed and claimed by Applicants. There is also no teaching that the acid cleaning solution may act as an electrolyte to cause copper electrolysis when PN junctions in a wafer are subjected to light illumination as disclosed by Edelstein et al. Moreover, Edelstein et al. do not disclose an

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electrolyte acidic cleaning solution nor suggest that the acidic cleaning solution of Zhang et al. may act as an electrolyte.

Thus, there appears to be no legitimate motive for combining Zhang et al. with Edelstein et al. other than Applicants disclosure. Nevertheless, assuming *arguendo* permissible combination of the references, such combination does not produce Applicants claimed invention. Applicants disclose and claim blocking the copper oxide containing surface from light illumination **while in contact** with the acidic cleaning solution rather than blocking the PN junction of Edelstein et al. from illumination while in contact with copper.

Applicants reiterate the above comments made with respect to Zhang et al. Kneer, like Zhang et al., discloses an acidic cleaning solution for cleaning copper following CMP planarization. However, Examiner does not articulate a proper motivation for combining Kneer with Edelstein et al. Moreover, Kneer discloses that the cleaning solution **slightly etches the copper** (see col 4, lines 54 - 65), thereby teaching away from Edelstein et al.'s disclosed and claimed invention and teaching a completely different principal of operation of **copper erosion**. The cleaning solution of Kneer would render the method of Edelstein et al. unsatisfactory for its intended purpose.



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Nevertheless, as explained above, even assuming *arguendo* proper motivation, such combination does not produce Applicants disclosed and claimed invention.

"First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. **The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure.**" *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

"If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification." *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

Applicants point out that "we do not pick and choose among the individual elements of assorted prior art references to

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recreate the claimed invention, but rather we look for some teaching or suggestion in the references to support their use in a particular claimed combination" *Symbol Technologies, Inc. v. Opticon, Inc.*, 935 F.2d 1569, 19 USPQ2d 1241 (Fed. Cir. 1991).

The claims have been amended to clarify Applicants disclosed and claimed invention and new claims added. A favorable consideration of Applicants' claims is respectfully requested.

Based on the foregoing, Applicants respectfully submit that the Claims are now in condition for allowance. Such favorable action by the Examiner at an early date is respectfully solicited.

In the event that the present invention as claimed is not in a condition for allowance for any other reasons, the Examiner is respectfully invited to call the Applicants' representative at his Bloomfield Hills, Michigan office at (248) 540-4040 such that necessary action may be taken to place the application in a condition for allowance.

Respectfully submitted,



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